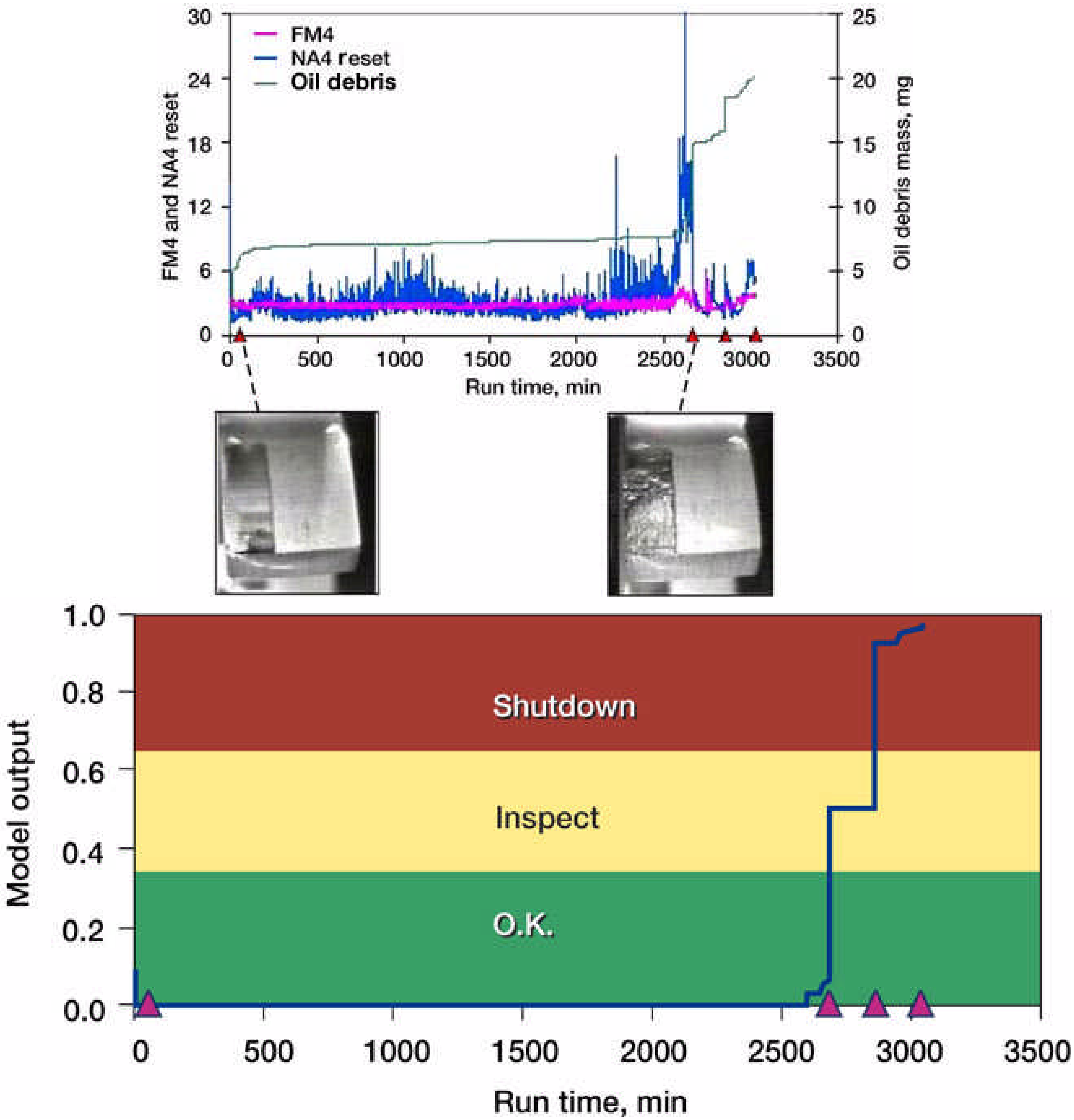
Gear Damage Detection Integrating Oil Debris and Vibration Measurement Technologies Developed



Top: Input to data fusion model. Readings were taken once per minute. Bottom: Output of the data fusion model.

The development of highly reliable health-monitoring systems is one technology area recommended for reducing the number of helicopter accidents. Helicopter transmission diagnostics are an important part of a helicopter health-monitoring system because helicopters depend on the power train for propulsion, lift, and flight maneuvering. One technique currently being tested for increasing the reliability and decreasing the false alarm rate of current transmission diagnostic tools is the replacement of simple single-sensor limits with multisensor systems integrating different measurement technologies.

The objective of this work was to integrate oil debris and vibration-based gear damage detection techniques into a health-monitoring system that can detect gear pitting damage. Vibration and oil debris data were collected from experiments in NASA Glenn Research Center's Spur Gear Fatigue Rig to demonstrate that the integration of two measurement technologies, oil analysis and vibration, results in a system with improved damage detection and decisionmaking capabilities in comparison to existing individual diagnostic tools.

Data were collected during 24 experiments using two accelerometers, an oil debris sensor, a speed sensor, and a load pressure sensor installed on the Spur Gear Fatigue Rig. The vibration data and speed data were used to calculate the gear vibration diagnostic algorithms FM4 and NA4 Reset. The oil debris mass data were collected using a commercially available inline oil debris sensor. A gear diagnostic parameter based on oil debris mass was developed as part of this work.

For this research, multisensor data fusion analysis techniques were applied to the gear damage data collected from the accelerometers and the oil debris sensor. This technique is a process similar to methods humans use to integrate data from multiple sources and senses to make decisions. Data from multiple sensors were combined so that inferences could be made that would not be possible from a single sensor. This yielded a simple system model that discriminates between the stages of pitting wear. Results indicate that combining the two technologies, oil debris and vibration, greatly improves the detection of pitting damage on spur gears. Integrating different measurement technologies and including expert knowledge of the diagnostician into the system (i.e., understanding the strengths and weaknesses of the diagnostic tools for different applications) enables clear decisions to be made on the health of the geared system.

The two plots on the preceding page show the data collected from one experiment with pitting damage. Readings were taken once per minute. The top figure shows the vibration algorithms FM4 and NA4 Reset along with the debris measured by the oil debris sensor during one experiment with pitting damage. The triangles indicate when the gear was inspected for damage. Damage began to occur at approximately reading 2669 during this experiment. The bottom figure is the output of the data fusion model used to integrate the oil and vibration data. This plot indicates to inspect the gears at reading 2669 (after 2669 min). As the damage increases, the inspect state changes to shutdown for this experiment.

Find out more about this research http://www.grc.nasa.gov/WWW/5900/5950/.

Bibliography

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